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Public Safety Leadership: Research Focus

# Engineering a Safer Society

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Evidence based policing continues to be an important area of discussion among police organisations across the world, and parallels are often drawn with medicine as a means to describe how a profession can be enhanced through a commitment to evidence based techniques. The use of the medical analogy in policing does not have everybody convinced, however, and there are those who argue that rather than molecules, bacteria and disease, we are dealing with the complexity of human behaviour, meaning simple cause and effect may always be difficult to establish. In this Research Focus Professors Nick Tilley and Gloria Laycock of the Jill Dando Institute at University College London extend this thinking and suggest that a better professional parallel might be drawn with engineering. Arguing that a process of evidence based trial and error might be more effective in policing than the experimental testing of narrow hypotheses, Professors Tilley and Laycock provide an important and thought provoking addition to the ongoing evidence based policing debate.

Engineering has been hugely successful. Aeronautical engineers have built ever safer, faster and more energy-efficient planes. Automotive engineers have likewise built faster, safer, increasingly energy-efficient vehicles. Civil engineers have designed skyscrapers that have become taller and taller and better able to survive earthquakes. Electronic engineers have created microcomputers and the Internet that now substantially shape our everyday lives.

In regard to public safety and security, engineers have designed mobile phones to be more easily traced when stolen, cars to become more difficult to steal, planes and airport-scanners to make hi-jacking more difficult, public buildings to be less vulnerable to ram-raids for theft or for bombing, and roads that reduce vehicle and pedestrian accidents. The list is almost endless.

Engineers and police officers have a lot in common. They both bring a 'can do' attitude to their work. They both focus on practical problems and try to formulate the best solutions they can to them. They are both constrained by limited resources. They both have to take the human dimension into account, where humans do not always behave according to expectations or hopes. They are both concerned with public safety, at least as part of their remit and are both apt to make serious mistakes from time to time with dire consequences. They both have a very long history, moving from on-the-job apprenticeship and craftwork to formal education and training. But policing cannot yet boast the same breadth or depth of cumulative achievement that is evident in modern engineering.

*If the police want a) to become more effective, b) to become more professional and c) to make use of science and the evidence used in science, then engineering may provide a tailor-made model for many of the problems faced by the police.*

How come engineers have been so successful? We highlight six important ingredients. In each case we give an example and then show how the ingredient relates to policing.

## 1. Engineers focus on solving problems in their specific setting

When engineers receive a commission, it is to formulate a solution to a particular problem, not in the laboratory but in specific real conditions. They may test parts of the proposed solution in a laboratory or in a computerized simulation model, but their primary interest is in producing a solution that will work in practice. They are increasingly adept at anticipating conditions in alien environments that they have not yet directly encountered, they try to build solutions that are robust enough to meet expected stresses, with some safety margin in the event that the calculations are too optimistic. Their solutions are also chronically constrained by resource limits, albeit that these constraints vary in their restrictiveness. Putting landing craft on Mars to send back information on the conditions there for analysis on Earth comprises a rather extreme, but intuitively obvious example (see: mars.nasa.gov/msl/mission/technology).

At its best, policing is also in the business of problem-solving. Indeed, Herman Goldstein (1979) developed his ideas on problem-oriented policing to emphasise how policing needs to identify specific, recurrent problems and formulate effective responses to them as a method of meeting public expectations of policing, whilst recognizing that resources are limited. The SARA model subsequently devised by John Eck and Bill Spelman (1987), to refer to Scanning, Analysis, Response and Assessment could equally describe what happens in engineering as new problems are identified and analysed in detail as a basis for devising novel responses whose test is their effectiveness in addressing the problem.

## 2. Engineers draw on formalised and tested theory

Engineers, both as students and throughout their careers, now learn and draw on a great deal of formal theory in analysing the problems they address, in formulating designs to deal with those problems and in estimating the expected consequences of their designs when they are put in place. The curricula for engineers are washed through with theory and mathematics. There is an extensive knowledge base for engineers that they are able to draw on with confidence, given that the ideas have been tested and built on over a long period. The education of engineers is largely concerned with conveying this to newcomers so that they are equipped to draw on it in their problem-solving efforts. When engineers test out their ideas, they are working within known limits of understanding.

*Contemporary engineers do not start from scratch, nor do they depend on common sense. Rather, they draw on elaborate, elaborated and well-tested theory that they can depend on in developing their design solutions.*

Look at any course outline for an undergraduate or graduate programme of engineering and the importance of tested theory and mathematics will be clear. The Wright brothers, Orville and Wilbur, furnish an interesting historical example. They were not university educated, but worked in their father's bicycle factory. However, in devising their plane they did ask the Smithsonian for all that had been written that was relevant to fixed wing flight, they did read and draw on Sir George Cayley's theory of flight, they did take account of and critically examine calculations made by their predecessors and they did empirically test the assumptions that lay behind those calculations. They were pioneers both in flight itself and in the application of systematic engineering methods.

Policing is also based on theory, but the theory is rarely explicit and often untested; policing depends on traditional 'wisdom' and craft learning. Nor are the police routinely and systematically taught that relevant theory which has been articulated and tested. Situational crime prevention is a rich source of tested theory that is not widely understood in policing. For example, the assumption that if used it will inexorably lead to displacement is an erroneous belief but one that is widely held. An engineering orientation would entail more testing of the theory that is taken for granted and more inculcation of the relevant tested theory that is available, for application to the specific problems the police need to address.

## 3. Engineers are creative

The creativity of engineers is obvious. We are surrounded by large and small artefacts, which are fruits of engineers' inventiveness. Trains, planes, automobiles, radios, television, computers, telephones, factories, printers, stoves, boilers, airports and even the humble pencil are all examples of engineering achievements. This is not say that all engineers are creative all the time, nor that what are created are always the fruits of inspired individual engineering geniuses. But the collective creativity of engineers is manifest.

James Dyson is famed for engineering creativity, but his products are the result of teams of engineers painstakingly developing new objects. At the time of writing Dyson's company is working on a revolutionary new lightweight hairdryer. This device uses a miniature fan with 13 rather than the normal 11 blades. The fan is sited in the handle of the dryer. It uses an 'air multiplier' to spew a stream of hot air through a hole. The temperature of the air is automatically monitored by a 'thermistor' and adjusted 20 times a second. The cost of these developments was some £50 million.

The main emphasis would be on gradual improvement, perhaps interspersed, as in technological developments with occasional major advances.

There are, to be sure, creative police officers. The solutions devised by bobbies in dealing with persistent problems leading to calls on the police are well attested in problem oriented policing work across the globe. The solutions can appear obvious in retrospect, but if they were really so obvious they would presumably have been implemented much earlier! One specific example relates to criminal damage to a tourist attraction in a public park. A path near the attraction was used as a shortcut. At nights, revellers would pick up stones and throw them at the windows. The police tried unsuccessfully to catch the people throwing the stones by lying in wait for them in the shadows. The creative solution was to persuade the park authorities to remove the loose gravel! The problem disappeared.

## 4. Engineers adapt their designs in the light of experience

Engineers try to formulate blueprints for their designs, but in practice adjustments have to be made as the work to develop a given artifact unfolds. A great deal of tinkering is needed to turn what is intended into reality; to make it work.

One example relates to the Boeing 747. When the engineering plans were put into practice, some 1,000lb of shims (thin, wedge shaped pieces) were needed to make parts of the fuselage fit with one another. When large buildings are erected structural engineers are on hand and are needed not only to check that the construction is faithfully meeting the standards incorporated into it to make it sound, but also to deal with the unforeseen contingencies that routinely arise.

The police too have standard operating procedures, reflecting the disciplined organisation of which they are a part, that are designed to provide for public safety. But specific events are encountered from time to time that require adaptation from the standard response. At such times police discretion can be used in a common sense way to try to produce better outcomes than those that would follow by sticking to a routine. The difference between the standards and discretion exercised by the engineer and police officer is that the former draws heavily on well-tested theory, while the latter lacks this as a rationale for his or her decisions and as such perhaps takes greater risks.

## 5. Engineers are fallible, but learn from their mistakes

Bridges do sometimes collapse, planes sometimes drop out of the sky, cars are apt to go wrong, and computers crash from time to time. Catastrophic failures, in particular, are investigated in detail in order to work out exactly what went wrong, with a view to ensuring that the same fatal flaw does not recur. Engineers focus heavily on failure. Indeed it is through identifying failures (preferably before a disaster occurs) that improvements are made.

The crashes of the De Havilland Comets in Calcutta in May 1953, in Rome in January 1954 and on Elba in April 1954 furnish one example. The plane had been built to tolerances that exceeded the expected strains that might lead materials to fail. Early mooted explanations for the initial crashes referred to extreme and abnormal weather conditions and pilot error. In the end, however, a structural fault at the corner of one of the windows was identified as the cause, which had been produced by the repeated pressurisation and depressurisation of the aircraft's cabin. Once it was identified this failure was remedied and Comets flew again.

*In engineering the issue is that of fault in the design, and how this might be remedied. In policing the issue is that of identifying the people who are at fault and how they can be blamed.*

There are certainly failures in policing and catastrophic examples are examined in great detail. In Britain the Hillsborough disaster, where 96 Liverpool football fans lost their lives, is a dramatic example where it was eventually concluded that they had been unlawfully killed. When things go awry in policing in Britain, the issue is generally put before the Independent Police Complaints Commission (IPPC). The focus of the IPPC in general and the focus in Hillsborough in particular bring out key differences between inquiries into faults in engineering and in policing. In engineering the issue is that of fault in the design, and how this might be remedied. In policing the issue is that of identifying the people who are at fault and how they can be blamed.The failing is a moral rather than a material one. The moral focus implies culpability and the issue of culpability leads to accusations, counter-accusations and cover-ups. This was, indeed, once the pattern with aircraft also. Leslie Wilkins (1997) reports his experience investigating failures in RAF aircraft. He highlights the need to separate blame from explanation. It is explanation, he argues, that can and did lead to improvements in aircraft design.

## 6. The effectiveness and efficiency of engineering has grown steadily and continues to grow

This essay began by highlighting some triumphs of engineering. They are difficult to miss. There have been a few dramatic breakthroughs, such as the Wrights achievement of fixed wing flight. More common, however, is gradual improvement over time, where past successes are drawn on, adapted and refined, often by teams of well-educated engineers working together rather than particular individuals.

The NASA Mars programme provides an example, which was worked on by a large team of engineers. They describe their work as follows:

Technology development makes missions possible. Each Mars mission is part of a continuing chain of innovation: each relies on past missions for new technologies and contributes its own innovations to future missions. This chain allows NASA to continue to push the boundaries of what is currently possible, while relying on proven technologies as well. (mars.nasa.gov/programmissions/technology, accessed May 3rd 2016)

Many engineering specialisms are involved in dealing with a host of problems in achieving a successful mission. These involve 'propulsion', 'power', 'telecommunications', 'avionics', and 'software engineering' dealing with 'entry, descent and landing', 'autonomous planetary mobility', 'technology for severe environments', 'sample return technologies', and 'planetary protection technologies'.

Policing also deals with complex problems, often requiring collaboration across specialisms and sometimes across organisations, including the police services themselves. It is also possible to point to accumulation in the capacity to address some types of problem. Football matches comprise one example where crowd control methods seem to have improved. That acknowledged, the kind of routine and continuous strengthening that characterises engineering is not embedded in the same way in policing not least because of the relative lack of attention to established theory.

## So what?

We want to argue that policing would benefit by embracing an engineering approach. We have noted important similarities in what each is trying to achieve in practice. But we have also noted key differences in detail and it is these that are instructive for helping policing to achieve the routine, continuous improvement that is so conspicuous in the case of engineering.

*We want to argue that policing would benefit by embracing an engineering approach.*

The first difference relates to applied theory. Engineers learn and draw on an established and tested body of theory that relates to the materials they use, how those materials behave and how they can be manipulated. The police are taught very little theory as a routine element of their training and indeed can be averse to theory. When they do draw on theory it is mostly implicit and untested. Engineers, in contrast, have a firm foundation in their understanding of theories for working out promising solutions to specific problems. Moreover, they have a large fund of well-documented and highly visible examples of successes from which to learn. Situational crime prevention is rooted in well-tested theory that is relevant to policing and there are plenty of examples of its practical application in dealing with specific problems that come to the attention of the police. Yet this is not what is normally taught to the police and it covers only part of the police mission.

The second difference relates to error, blame and learning. We have emphasised the fact that errors are common to policing and engineering. Yet they are treated very differently. Engineers are obsessed with finding weaknesses and remedying them, wherever possible before they endanger human beings. They stress stresses. They monitor them. They cautiously build safety margins into their designs, especially where failures risk calamities. Where catastrophic errors do survive the developmental tests that engineers undertake, the diagnosis of weakness is firmly focused on lessons learned for the future. The blameworthy treatment of error in policing militates against fruitful lesson-learning and the corrections that can be made in the future. Personalising mistakes gets in the way of learning those impersonal lessons that engineers draw on in achieving improvement.

Third, engineers are inveterate tinkerers both as they turn their plans into reality and as they attempt to improve performance. Although often proud of their achievements, engineers restlessly search for ways of making things work better. Even when first efforts fail, engineers are apt to persist with attempted solutions to problems that are rooted in well-established theory. All this contrasts with policing where there is plenty of innovation, but much less tinkering and much less attention to fine-tuning in the interest of achieving continuous improvement. There is a risk here that net pass/fail verdicts on standard practices will a) mask real variations in outcomes across sub-populations, b) lead to uncritical adoption or rejection of solutions that may not be appropriate to specific conditions and c) inhibit the search for those continuous improvements that mark out engineering as an applied activity.

An engineering agenda for policing would have widespread implications.

- **For human resources** it would mean a heavy emphasis on developing staff with a strong understanding of applied theory as it relates to dealing with the problems that the police address, including those relating to traffic and disorder, as well as crime. Meeting the need for a good understanding of applied theory would run through recruitment, education and training and staff development.
- **For management** it would mean concentrating on continuous improvement by tinkering thoughtfully with responses to problems, by attending routinely to small failures and by trying to learn from them.
- **For research and development** it would mean a) helping to articulate and test theories currently taken for granted and b) a heavy investment in formulating detailed strategies whose component parts are carefully tested before implementation, in the expectation that they will still need fine-tuning.
- **For oversight and accountability** it would mean either a) abandoning the present focus on finding where blame lies and focusing instead on diagnosing what practices lay behind failures, especially catastrophic ones, or b) making a clear and explicit distinction between blame-focused and explanation-focused enquiries targeted at improvement.

The overall aim of adopting an engineering approach would be the achievement of cumulative improvements in police measures, where the past is continuously built on in the interests of public safety. Instead of the kind of pass-fail and effect-size verdicts that tend to be produced in what is often referred to as evidence-based policing, the main emphasis would be on gradual improvement, perhaps interspersed, as in technological developments, with occasional major advances.

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